Ontario

Amendments to Noise Requirements in the Regulations for Industrial Establishments & Oil and Gas-Offshore

Health and Safety Guidelines

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Amendments to Noise Requirements in the Regulations for Industrial Establishments & Oil and Gas-Offshore

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1. INTRODUCTION:

This guideline is intended to provide information and assistance to employers in complying with the amended noise requirements in the *Regulations for Industrial Establishments (Regulation 851, section 139)* and the *Regulation for Oil and Gas-Offshore (Regulation 855, section 41)*. These amendments were made under O.Reg 565/06 and O.Reg 566/06, and come into effect July 1, 2007.

The guideline does not include general information regarding noise and how it affects the human ear. The Canadian Centre for Occupational Health and Safety (CCOHS) web site [1] has excellent resources in this regard.

The guideline does not prescribe how employers conduct noise assessments or how to control worker exposure to noise. It is not intended as a textbook on noise assessment and control, merely as a guide to understanding the regulatory requirements and resource material that may be helpful in achieving compliance. Note that links provided to internet resource sites were valid at the time the guideline was issued, but maintenance of those sites is outside the control of the Ministry of Labour.

The information contained in this guideline is not intended to be all-inclusive nor should it be interpreted as replacing or modifying the requirements of the Occupational Health and Safety Act, Regulation 851, or Regulation 855 as amended. In any case where this guideline may differ from the regulations, the provisions in the regulatory section prevail.

2. HAZARD

Noise is a serious hazard in many workplaces. Over time, if exposure to noise from machinery, processes, and equipment is not properly eliminated or controlled, it may cause permanent hearing loss in workers.

Exposure to high levels of noise in the workplace, may also create physical and psychological stress, reduce productivity, interfere with communication, and contribute to accidents and injuries by making it difficult to hear moving equipment, other workers, and warning signals.

Hearing loss can have a significant impact on quality of life for workers and their families. In 2006, the Workplace Safety and Insurance Board (WSIB) estimated that the average cost of equipment (a set of hearing aids and batteries) for workers with noise-induced hearing loss, can reach $11,000 every four years, payable from the time the claim is approved until the death of a worker. In the case of a 55-year-old worker who lives until the age of 83, the equipment costs could reach $100,000. Workers with approved claims may also be eligible for future economic loss and non-economic loss awards, in addition to hearing aids and batteries.

The intent of the amended noise requirements is to ensure that the hazards associated with the exposure of workers to noise are eliminated or properly controlled.

3. REGULATION

The amended Regulations (851 and 855) contain 3 key requirements, which may be summarised as follows:

a) Employers are to take all measures reasonably necessary in the circumstances to protect workers from exposure to hazardous sound levels that result in the $L_{ex,8}$ exposure limit of 85 dBA being exceeded (8-hour time-weighted average exposure)

b) When the exposure limit prescribed by the regulations is exceeded, the employer is required to put in place measures to reduce workers' exposure. Protective measures may include: engineering controls to reduce noise at the source or along the path of transmission; work practices such as equipment maintenance (to keep it quieter), or scheduling to limit a worker's exposure time; and, personal protective equipment in the form of hearing protection devices, subject to the restrictions stated in the regulations

c) Employers must post clearly visible warning signs at the approaches to areas where the sound level regularly exceeds 85 dBA

The following sections quote provisions of the regulations in italics, and provide guidance beneath each excerpt.

a) Noise Exposure Limits

"Every employer shall ensure that no worker is exposed to a sound level greater than an equivalent sound exposure level of 85 dBA, $L_{ex,8}$".

What limits apply?

The only applicable exposure limit is the 85 dBA, $L_{ex,8}$.

A worker's exposure to noise levels generally varies throughout the day. An 85 dBA $L_{ex,8}$ may be thought of as the permissible time-weighted average noise exposure that is averaged over an 8 hour shift.

This is similar in concept to the Time-Weighted Average Exposure Value (TWAEV) for a chemical substance in the Regulation respecting Control of Exposure to Biological or Chemical Agents (Regulation 833).

Note that by using appropriate instrumentation, impulsive or impact noise is automatically included in the measurements used to determine $L_{ex,8}$ exposure levels.

Appendix A discusses measurement equipment, selection, and use limitations.

There is no "ceiling" exposure limit for continuous noise and no maximum "peak" noise criterion. These are considered unnecessary, owing to the nature of the 85 dBA, $L_{ex,8}$ exposure limit. National Institute for Occupational Safety and Health (NIOSH) [2] has stated that a maximum or "ceiling" exposure limit for continuous type noise is considered unnecessary with an 85 dBA criterion level and a 3 dB exchange rate, both of which are inherent in the 85 dBA, $L_{ex,8}$ exposure limit. Similarly, a 140 dBC maximum "peak" noise criterion is unnecessary because exposure to such a sound level would result in the 85 dBA $L_{ex,8}$ exposure limit being exceeded in a fraction of a second.

How are noise exposures assessed?

Although the definition of equivalent sound exposure level in the regulations includes the formula set out in subsection (2), it is not anticipated that this equation will be widely used to determine $L_{ex,8}$. The sound level or L_{eq} measurement(s) used to determine an $L_{ex,8}$ exposure level can be made using a noise dosimeter, an integrating sound level meter, or in some circumstances, a basic sound level meter. The Canadian Standards Association [3] provides guidance on equipment selection and specifications and on procedures for the measurement or calculation of L_{eq} and $L_{ex,8}$.

Compliance with Ontario's regulatory requirements respecting noise exposure control does not necessarily mean that a comprehensive noise survey needs to be done in every workplace. Many employers will have previous sound level or dosimetry data that may be useful in assessing worker exposures and the likelihood of them exceeding the occupational exposure limit. Exposure data for a group of workers with the highest noise exposures may be useful to infer compliance for less exposed groups.

Even in the absence of such data, a crude assessment may be possible based on the ease or difficulty of speech communication at a normal conversation distance of about 1 meter. If it is necessary to speak very loudly, the sound level probably exceeds 85 dBA. This concept has been expanded upon by Malchaire.[4]

However, it would be appropriate for an employer to carry out a noise exposure survey using more sophisticated measurement tools if area sound levels are high enough to require speaking very loudly to communicate and action has not been taken to reduce them. Other indicators that a noise exposure survey is needed include use of equipment known to produce sound levels above 80 dBA in published data, worker complaints

regarding noise and symptoms, or audiometric test results showing early signs of noise induced hearing loss.

Employers may contact their Safe Workplace Association [5] referenced at the end of this document, or consultants specializing in noise assessments to assist them with assessing $L_{ex,8}$ in their workplace, if they do not possess the required instrumentation, resources, or knowledge to carry these out where required. Also, the Occupational Health Clinics for Ontario Workers has published a useful Noise Calculator spreadsheet on their web site. [6]

See Appendix A for more detailed information about noise measurement equipment and Appendix B regarding the determination of $L_{ex,8}$.

b) Protective Measures

"Every employer shall take all measures reasonably necessary in the circumstances to protect workers from exposure to hazardous sound levels."

This requirement is intended to protect workers from exposure to sound levels that would result in noise exposure above the 85 dBA, $L_{ex,8}$ exposure limit. This does not mean that protection is required only where area sound levels exceed 85 dBA. For example, a 12-hour exposure to 84 dBA would mean that worker protection is mandated, because the $L_{ex,8}$ exposure limit would be exceeded.

"Any measurement of sound levels in the workplace that is done in order to determine what protective measures are appropriate shall be done without regards to any use of personal protective equipment."

All sound level measurements conducted for purposes of assessing noise exposures must be conducted without regards to the attenuation factor / safety factor provided by personal protective equipment (i.e. hearing protection devices - HPD) being worn by the workers. Exposures are calculated assuming that workers are unprotected by HPDs.

*"The protective measures shall include the provision and use of engineering controls, work practices and, subject to subsection (*described below*), personal protective equipment."*

Similar to an occupational exposure limit for a hazardous chemical substance, when a worker is exposed to a daily noise dose exceeding the limit of 85 dBA $L_{ex,8}$, the employer must take measures to reduce the exposure to noise. Measures may include engineering controls to reduce noise at the source or along the path of transmission, work practices (i.e. administrative controls such as limiting a worker's exposure time, maintaining equipment), or personal protective equipment (i.e. hearing protection devices) subject to the restrictions below.

This requires the employer to consider all 3 types of controls to protect workers against noise, but does not necessarily expect the employer to use all 3 types for every situation.

As an example of work practices, also referred to as administrative controls, worker assignments in a noisy area could be rotated to limit the total shift exposure of each worker to an acceptable level. The benefits of this approach are somewhat limited, because the daily exposure of a worker has to be cut in half to reduce the $L_{ex,8}$ exposure by 3 dBA.

A more effective administrative control is a good preventive maintenance program to prevent equipment from becoming significant sources of noise. Also, developing and implementing maximum noise specifications for the purchase of new equipment is worthwhile, because it is usually cheaper to include noise controls at the design stage than to retrofit controls on existing equipment. CSA Standard Z107.58 [7], Noise Emission Declarations for Machinery, provides guidance for specifying equipment using internationally recognised standards and procedures.

Engineering controls along the path of transmission generally mean introducing enclosures, partial enclosures, or barriers. These can be structures that enclose a piece of noisy equipment or enclose a work station in a noisy area.

There are many types of engineering controls at the source. The selection of which ones to apply in a given instance requires an assessment of the cause of the noise at that source. Some examples are: installing mufflers on air exhausts; purchasing quiet air jet nozzles; applying mechanical damping treatment to metal panels in impact situations; using vibration isolators on vibrating equipment; redesigning noisy saw blades or press dies; installing absorbent panels on building surfaces near noisy tools; and substitution of quieter machines, tools or processes, such as hydraulic rather than pneumatic power.

See Appendix C for more detailed information regarding noise controls.

There are various resources available online discussing control measures such as: NIOSH[8], CCOHS [9], and NPC [10].

Employers may contact their Safe Workplace Association [5], referenced at the end of this document, or consultants specializing in the design and fabrication of such noise controls. Most noise control equipment is available commercially. Acoustical consultants with experience in industrial settings can often provide effective solutions for specific noise sources or for reducing noise exposures generally in a facility.

"The employer shall protect workers from exposure to a sound level greater than the limit without requiring them to use and wear personal protective equipment."

The preferred and most effective way to control noise exposure is through engineering controls at the source or along the path of transmission. In keeping with good health and safety practice, hearing protection devices (HPDs) should always be considered as a last resort.

Engineering and administrative controls are preferable to HPDs because these devices are often less protective than their ratings, due to such factors as improper selection, poor fit, deterioration, user discomfort, and lack of user motivation.

"Workers shall wear and use personal protective equipment appropriate in the circumstances to protect them from exposure to a sound level greater than the limit" only if *"engineering controls"*,

a) are not in existence or are not obtainable;

b) are not reasonable or not practical to adopt, install or provide because of the duration or frequency of the exposures or because of the nature of the process, operation or work;

c) are rendered ineffective because of temporary breakdown of such controls; or

d) are ineffective to prevent, control or limit exposure because of an emergency."

This subsection reinforces that personal protective equipment should only be used as a control measure as a last resort, and further qualifies when it can be relied on for worker protection. It should be noted, however, that nothing in the regulations precludes use of HPDs for noise exposures below 85 dBA and such use is considered advisable for exposures to sound levels above 80 dBA.

The phrase "not reasonable or not practical to adopt, install or provide" is intended to allow use of hearing protection devices where an evaluation of other control measures indicates they are not practical or reasonable based on their effectiveness, cost, technical feasibility or implications for equipment use, service and maintenance.

To demonstrate compliance with this requirement, an employer should document what other measures have been considered and why those measures are not adopted, since they may be asked to provide such information.

For situations where employers rely on HPDs to protect workers against excessive noise exposures, the employer must ensure that the HPDs are appropriate and effective for the purpose. This means that employers are expected to develop and have a hearing protection program that includes training on the proper selection, use, and care of HPDs. Both CSA [11] and NIOSH [12] have additional guidance in this regard.

While it is always important to control sound levels and worker exposure to noise before relying upon hearing protection devices and to select HPDs that are appropriate for the circumstances, HPD selection is even more critical in extreme noise environments. Sound levels in excess of 105 dBA may be considered extreme noise environments. Where it is not reasonable or practical to reduce the sound levels below 105 dBA and minimize worker exposure durations, special HPDs or dual protection from ear plugs and ear muffs may be necessary.

When selecting HPDs, it is often incorrectly assumed that the Noise Reduction Rating (NRR) on the package accurately predicts the dBA reduction that the device will provide.

This is untrue for two reasons.

First, the NRR is designed for use with C-weighted sound measurements, so if only A-weighted data are available there must be an adjustment to account for the difference between A-weighting and C-weighting.

Second, the data used to determine the NRR for a device are normally obtained under laboratory conditions, so devices must be "derated" to account for the significantly reduced protection provided under "real world" conditions.

Employers who use the NRR method to select hearing protection devices need to consider both of these factors when discussing the purchase of appropriate HPDs for their specific workplace noise environment.

NIOSH [11] addresses correct use of NRRs taking both of these factors into account.

Also, see Appendix D for further discussion of HPD selection.

Although not required by the regulations, it is considered good health and safety practice for an employer, in consultation with the Joint Health and Safety Committee (JHSC), to implement a hearing conservation program that includes audiometric testing of workers regularly working in areas with noise levels exceeding 80 dBA. This benefits both workers and employers by identifying potential gaps in the noise exposure control program.

c) Warning Signs

"A clearly visible warning sign shall be posted at every approach to an area in the workplace where the sound level measured as described, regularly exceeds 85 dBA."

The purpose of the signage requirement is to advise anyone, even non-workers, that they are entering an area, that is, or may become, loud enough to cause damage to their hearing if unprotected, depending on the length of time they spend in the area. This requirement is intended to support a fundamental principal of the Internal Responsibility System (IRS), which is the worker's right to know.

The intent of this section is for the employer to post a sign at every approach to an area where continuous or intermittent noise levels regularly exceed 85 dBA due to work that is normally conducted in that area. This would include intermittent noise from power tools, or equipment normally used in the area, but would exclude noisy one-time or rare activities that are not part of the regular activities in the area. However, if an area routinely exceeds 85 dBA, either continuously or intermittently, (i.e. press operation, pneumatic or electric grinder use), a sign or signs must be posted.

What must the sign indicate?

It is ultimately left to each employer to decide on what kind of warning the sign should provide, but it is recommended that the sign advise workers that there is a potential for hearing loss in that area, if unprotected, and what measures are to be taken to control this potential exposure.

The content of the signs may include, but is not limited to:

- Identification of actual sound level in dBA
- Warning of hazardous sound levels
- Requirement for mandatory hearing protection in the area
- Providing the allowable exposure duration for this area, without hearing protection
- Icons indicating that hearing protection is to be worn
- Other form of controls required

Words on the signs may be in whatever language is appropriate for the workplace, but will normally be in English and the majority language of the workplace.

Endnotes

[1] CCOHS What are Sound and Noise:
http://www.ccohs.ca/oshanswers/phys_agents/noise_basic.html

[2] NIOSH Criteria Document at www.cdc.gov/niosh/docs/98-126/chap3.html

[3] CSA Standard Z107.56 - 06 *Procedures for the Measurement of Occupational Noise Exposure* www.ShopCSA.ca

[4] J Malchaire, Strategy for prevention and control of the risks due to noise, in Occup Environ Med 2000; 57:361-369

[5] Safety Associations and WSIB - www.wsib.on.ca/wsib/wsibsite.nsf/public/Partners

[6] Occupational Health Clinics for Ontario Workers Noise Exposure Calculator
http://www.ohcow.on.ca/menuweb/noisecalculator.xls

[7] CSA Standard Z107.58 – 02, *Noise Emission Declarations for Machinery* www.ShopCSA.ca

[8] The National Institute for Occupational Safety and Health (NIOSH) in the USA has published an extensive on-line Noise Control Manual at: http://www.cdc.gov/niosh/79-117pd.html

[9] The Canadian Centre for Occupational Health and Safety (CCOHS) offers an inexpensive document titled "Noise Control in Industry: A Basic Guide." Information about the guide and how to obtain it is available at:
www.ccohs.ca/ccohs/releases/noiseguide.html

[10] Noise Control – A Guide for Workers and Employers
http://www.nonoise.org/hearing/noisecon/noisecon.htm

[11] CSA Standard Z94.2 – 02 Hearing Protection Devices —Performance, Selection, Care, and Use www.ShopCSA.ca

[12] NIOSH Hearing Protector Device Compendium Search web site at www2a.cdc.gov/hp-devices/hp_srchpg01.asp

APPENDIX A

Noise Measurement Equipment

In general, the following instruments are appropriate for the measurement of occupational noise exposure (adapted from CSA Standard Z107.56-06, Procedures for the measurement of occupational noise exposure):

1. A sound level meter that meets at least the Type 2 requirements of ANSI S1.4 or IEC 61672, used on an A-weighting network and on slow response.

2. An integrating sound level meter that meets at least the Type 2 tolerance requirements of ANSI S1.4 or IEC 61672-1, with an A-weighting network , a dynamic range of at least 50 dB, and a crest factor capability of at least 30 dB. "Dynamic range" is the range in dB over which the instrument operates within the tolerances stated by the manufacturer. "Crest factor" is the difference in dB between the peak sound pressure level and the equivalent sound pressure level measured over a specified time interval.

3. A noise dosimeter with Type 2 tolerance according to ANSI S1.25, ANSI S1.4 or IEC 61672-1, with an A-weighting network, a dynamic range of at least 50 dB, a crest factor capability of at least 30 dB, and a threshold level at least 10 dB below the applicable criterion level (in this case, 75 dBA or less). Dosimeter settings should be: 85 dBA criterion level; 3 dB exchange rate; and threshold no higher than 75 dBA (preferably zero).

The following CSA table may be used as a guide in selecting the most appropriate instrument:

Instrument selection

A dosimeter, integrating sound level meter, or sound level meter may be used to determine noise exposure. The following table may be used as a guide in selecting the most appropriate instrument:

Instrument	Uses	Limitations
Dosimeter	All occasions, particularly when a worker cannot be accompanied or work has an unpredictable pattern. Most useful when work cannot be easily split into discrete activities.	Maximum sound level may exceed instrument range. Crest factor of sound may exceed instrument capability. Data collection is difficult to witness.

Instrument	Uses	Limitations
Integrating sound level meter	All occasions. Most useful when work can be easily split into discrete activities.	Maximum sound level may exceed instrument range. Crest factor of sound may exceed instrument capability where workers are exposed in an unpredictable fashion to different sound levels. However, in many cases a space average over the working area can provide a good estimate of the noise exposure of such people.
Sound level meter	Only useful when work can be easily split into discrete activities during which sound levels are steady.	Cannot adequately measure non-steady (> ±3 dB) or impulsive sound.

Notes:

(1) *Crest factors exceeding 30 dB are rare but may occur with highly impulsive sounds such as those produced by drop forging and blasting. In these cases, an instrument with a higher crest factor capability should be used.*

(2) *A side benefit of the use of an integrating sound level meter is the possibility of identifying the contribution to workers' noise exposure of different activities and noise sources for later use in a noise-control program. Logging dosimeters may also be useful for generating this information.*

(3) *A sound level meter can sometimes be used to define high noise level areas in which hearing protectors should be worn.*

(4) *When sound levels vary slowly enough to allow readings to be taken, a sound level meter may be used to obtain $L_{p,i}$ by taking a series of measurements at regular intervals. The $L_{eq,t}$ can then be calculated from $L_{p,i}$ using Clause C.3.*

(5) *Some instruments can be affected by radio interference and strong electromagnetic fields. This situation can be verified by using a dummy microphone or a calibrator fitted but not turned on, to attenuate the noise at the microphone. If the sound level measured does not drop significantly, interference should be suspected.*

(6) *In many cases the same instrument can be used either as a dosimeter or as an integrating sound level meter.*

(7) *The use of dosimeters and integrating sound level meters can complement each other. It is recommended that both types of measurement be taken as a cross-check of the results. In many cases, the same instrument can be used for both.*

(8) *There is evidence of a systematic difference of up to 2 dB between readings obtained using dosimeters and integrating sound level meters. This Standard*

does not provide a correction for this effect but instead attempts to specify microphone locations (on the outer edge of the shoulder) to minimize it. It is expected that other sources of variation will tend to obscure this effect in most cases.

As stated in Note (1) below the table, a dosimeter or integrating sound level meter with a higher crest factor capability must be used for highly impulsive noise such as the sounds produced by a drop forge or blasting operations.

In their 2006 Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices, the ACGIH (American Conference of Governmental Industrial Hygienists) states, "By using the instrumentation specified by ANSI S1.4, S1.25, or IEC 804, impulsive or impact noise is automatically included in the noise measurement. The only requirement is a measurement range between 80 and 140 dB and the pulse range must be at least 63 dB." "Pulse range" is the difference in dB between the peak level of an impulse signal and the root mean square or geometric average.

APPENDIX B

Calculating $L_{ex,8}$

If a worker's exposure to noise throughout a shift can be characterized by a number of L_{eq} measurements for distinct noise activity periods, the measurements can be combined into a full shift L_{eq} using the equation:

$$L_{eq,shift} = 10 \text{ Log } [(1/T) (T_1 \times 10^{0.1L_1} + T_2 \times 10^{0.1L_2} + ...+T_n \times 10^{0.1L_n})]$$

where

T is the shift length, hours
T_n is the duration of the n^{th} measurement, hours
L_n is the L_{eq} for the n^{th} measurement period, dBA

For example, if a worker's exposure consists of two distinct exposure periods, 3 hours at an L_{eq} of 84 dBA and 5 hours at an L_{eq} of 88 dBA, then:

$$L_{eq,8} = 10 \text{ Log } [(1/8) \{(3 \times 10^{0.1 \times 84}) + (5 \times 10^{0.1 \times 88})\}] = 86.9 \text{ dBA} = L_{ex,8}$$

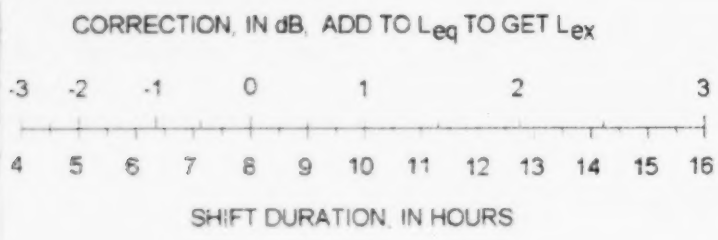
For a shift length greater or less than 8 hours, the $L_{ex,8}$ may be calculated using the equation:

$L_{ex,8} = L_{eq,T} + 10\text{Log}(T/8)$, where T is the shift duration in hours.

For example, an L_{eq} for a 10 hour shift would be converted to an $L_{ex,8}$ as follows:

$L_{ex,8} = L_{eq,10} + 10\text{Log}(10/8) = L_{eq,10} + 1$ dBA

The same result can be obtained using the following nomograph, which shows the correction in dBA to be made to the L_{eq} for different shift durations.



In this nomograph the numbers below the line represent the actual shift duration in hours and the numbers above the line are the corresponding correction factor to be added to the shift L_{eq} to convert it to an $L_{ex,8}$.

For a 10-hour shift, the nomograph shows a +1 dBA correction to the L_{eq}. Therefore, if a worker is exposed to a measured level of 88 dBA L_{eq} for a period of 10 hours, the $L_{ex,8}$ would equal 88 dBA + 1 dBA, or 89 dBA.

For a 12-hour shift, the nomograph shows a 1.7 dBA correction (or more appropriately, a 2 dBA correction since measurement accuracy of better than +/-1 dBA is unlikely). Thus a worker exposed to 83 dBA for 12-hours would have an $L_{ex,8}$ exposure of 83 + 2 = 85 dBA. Another way of looking at this is to consider the 12-hour shift L_{eq} (or $L_{ex,12}$) limit to be 83 dBA.

Where a worker's noise exposure can be easily split into discrete activities during which sound levels are steady, the following Table may be used to calculate the L_{eq} for the shift.

TABLE OF EQUIVALENT NOISE EXPOSURES

Steady Sound Level dBA	Duration
82	16 hours
85	8 hours
88	4 hours
91	2 hours
94	1 hour
97	30 minutes
100	15 minutes
103	7.5 minutes
106	3.75 minutes
109	1.88 minutes

Where a worker is exposed to a steady sound level throughout his/her shift, the exposure duration must not exceed the value for that sound level in the above Table. Once the worker has reached the permissible duration for that sound level the worker's noise exposure has reached 100% of the permissible daily noise dose. For example, if a worker is exposed to a steady sound level of 91 dBA, the maximum permissible daily exposure duration is 2 hours. Additional noise exposure at any level above 75 dBA would exceed the 85 dBA $L_{ex,8}$ exposure limit and require measures to protect the worker's hearing.

Where the daily noise exposure is composed of two or more periods of noise exposure of different levels, the following equation may be used to determine if the overall exposure exceeds the allowable noise exposure limits:

$$(C_1/T_1 + C_2/T_2 + \ldots C_n/T_n) \times 100 = \% \text{ of exposure limit}$$

Where

C = total duration of exposure at a specific noise level, and
T = total duration of exposure permitted at that level

The 85 dBA $L_{ex,8}$ exposure limit is exceeded when the dose, calculated using the above formula exceeds 100%.

Example:

A worker is exposed to 85 dBA for 4 hours and 91 dBA for 1.5 hours.

Therefore using above calculation:

$$(4/8 + 1.5/2) \times 100 = 125\%$$

In this case the worker has exceeded his/her allowable noise exposure and therefore measures must be implemented to protect the worker's hearing. If the exposure duration at 91 dBA were reduced to 1 hour, the combined exposure would be at 100% of the permissible daily noise dose, provided the worker's exposure is below 75 dBA for the rest of his shift.

APPENDIX C

Noise Controls

Noise Source	Approach	Principle
Air Exhaust	Air Exhaust Muffler	Spreads air exhaust over many small holes to reduce velocity.
Air Jet	Air Thrust Nozzle (for cooling, cleaning, drying or moving)	Entrains air to primary jet to increase airflow at a slower speed, i.e. quieter but with increased thrust.
Fan	Inlet or Outlet Silencer	Absorbs sound in baffles lined with fiberglass or mineral wool. Specification requires some expertise.
New Electric Motor (most often required for 3600 rpm and higher)	Quiet Line Motor	Available in most sizes and speeds. Usually higher efficiency than conventional noisy motor. Much better option than quieting after purchase.
Existing electric motor	Motor silencer/motor mute	Silences motor cooling fan, usually the major noise source. Must be sized not to overheat motor. Better to buy a quiet motor in the first place.
"Singing" motor	Filter electric power supply	Power supplies producing DC or current for variable speed motors often produce audible harmonics in the regular plant power system.
New flow valves	Buy to meet noise specification	Most valve selection programs will help select quiet valves. These are premium price, but often worth the extra cost.
Existing loud valves (usually high pressure drop)	Quiet trim valve	Quiet trim can be retrofit in existing valves in some situations to make them considerably quieter.
Existing loud valves (usually high pressure drop)	Orifice plate	Introduce an orifice plate across the pipe to reduce pressure drop across the noisy valve.
Flow noise in pipes	Repair leaks and insulate pipes	Acoustical insulation can reduce noise from piping, but in some cases must extend a considerable distance from a noisy valve.

Noise Source	Approach	Principle
Flow noise in pipes	Wrap acoustical lagging around pipes	Wrap pipes in a composite of mineral wool blanket covered with metal jacket or loaded vinyl.
Pump rooms and other similar small equipment rooms	Line with sound absorbing material	Small industrial rooms can be highly reverberant, increasing sound levels inside.
Separate different circuits	Allows shut down circuit to be worked on under quiet conditions while other circuit continues to operate.	
Isolated, noisy, automatic equipment	Noise enclosure with heavy (steel) outer shell and sound absorbing lining (fiberglass)	Must be designed to provide inspection, light, access, maintenance and adequate cooling.
Hydraulic equipment	Isolate from drip trays and tanks, insulate hoses and enclose pump if necessary	Can often be specified quiet.
Ventilation openings	Acoustical louvres	Provide about 10 dB attenuation with 50% free area.

APPENDIX D

Hearing Protector (HPD) Selection

Methods of selecting HPDs are based on the measurement and statistical treatment of octave band sound attenuation data for test subjects. Until 1997, the standard for testing was ANSI Standard S3.19-1974, which tested subjects under "laboratory conditions." ANSI Standard S12.6-1997, Method B, tests sound attenuation under "real world" conditions, where the protection provided is much less than under the laboratory conditions previously used. However, much of the sound attenuation data in use today is still ANSI S3.19-1974 data, including the NRRs (Noise Reduction Ratings) that manufacturers print on their packages of HPDs. Consequently, NIOSH recommends derating NRRs by a multiplicative factor of 75% for earmuffs, 50% for foam earplugs and custom plugs, and 30% for all other ear plugs (i.e. NRR x 0.75 for muffs, NRR x 0.5 for foam plugs and custom plugs, and NRR x 0.3 for other ear plugs).

There are various methods of selecting HPDs. The most accurate, but most complicated, are octave band procedures. Octave band computation, as described in s.9.8.6.1 and in Appendix B of CSA Standard Z94.2-02, requires measurement of the unweighted workplace sound levels in the 125, 250, 500, 1000, 2000, 4000, and 8000 Hz octave bands and the octave band attenuation data for the HPD being assessed. Below is an example of how to estimate the effective noise level by this method when wearing a particular HPD:

Octave-band Centre frequency (Hz)	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**Overall level**
Workplace noise spectrum	85	88	93	90	89	87	86	
Mean attenuation of HPD	12	15	20	26	31	37	35	
Std. dev. of attenuation	2.8	3.0	4.0	3.7	4.9	5.9	4.0	
Assumed protection values	9.2	12.0	16.0	22.3	26.1	31.1	31.0	
A-weighting coefficients	-16.1	-8.6	-3.2	0.0	+1.2	-1.0	-1.1	
Effective A-weighted (dBA)	59.7	67.4	73.8	67.7	64.1	56.9	53.9	76.0

The estimated protected exposure level is calculated using the following equation:

Overall level = 10 log ($10^{5.97}$ + $10^{6.74}$ + ...+ $10^{5.39}$) = 76.0

CSA Standard Z94.2-02 requires use of this method for exposures above an $L_{ex,8}$ of 110 dBA.

NIOSH provides an online octave band selection method using ANSI S12.6-1997, Method B data in their Hearing Protector Device Compendium Search web site

To simplify HPD selection, NIOSH developed a single number rating system, the Noise Reduction Rating (NRR). The system was designed for use with C-weighted sound level measurements, as follows:

Protected A-weighted exposure = Unprotected C-weighted exposure – NRR

NIOSH also suggested that unprotected A-weighted data may be used in place of C-weighted data by adding a +7 dB correction factor to the A-weighted sound level to estimate the C-weighted sound level, as follows:

Protected A-weighted exposure = Unprotected A-weighted exposure + 7 – NRR

As previously stated however, NRRs are based on laboratory data rather than real world data, so NIOSH now recommends that NRRs be derated for use in the above equations. For example, given a muff type of HPD with an NRR of 32 and an unprotected exposure level of 94 dBA, the derated NRR would be 32 x 0.75 = 24 and the protected A-weighted exposure would be estimated as:

Protected A-weighted exposure = 94 dBA +7 – 24 = 77 dBA

NIOSH also provides this selection method on their HPD compendium search web site.

CSA Standard Z94.2-02 provides a similar Single Number Rating System, the SNR (SF84). It is also designed for use with C-weighted exposure measurements, but it is based on "real world" test data (ANSI S12.6-1997, Method B). It is the value that would be achieved by 84% of the using population in a well run hearing conservation program. The SNR (SF84) is used by subtracting it from the unprotected C-weighted sound level or exposure ($L_{ex,8}$) to calculate the effective A-weighted level or exposure. For example, if the measured L_{eq} is 98 dBC and a particular HPD has a SNR (SF84) rating of 22 dB, the predicted A-weighted effective L_{eq} when wearing this device is:

98 – 22 = 76 dBA

CSA Standard Z94.2-02 also provides a method for HPD selection based on either a grading or classification system in conjunction with sound exposure data (i.e. $L_{ex,8}$). Classes are the "old" CSA system in which HPDs are assigned to Class A, B, or C, based on laboratory attenuation data. In the "new" CSA system, grades are 0, 1, 2, 3, or 4, based on real world attenuation data, the SNR (SF84). A table (Table 4) is provided in the standard that specifies the recommended CSA Grade or Class for given values of the $L_{ex,8}$ exposure.

General References

CSA Standard Z107.10 Guide for the Use of Acoustical Standards in Canada
www.ShopCSA.ca

Workers' Compensation Board of BC – Occupational Noise Surveys -
http://www.worksafebc.com/publications/health_and_safety/by_topic/assets/pdf/occupational_noise_surveys.pdf

ACGIH Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices
www.acgih.org/tlv

WSIB Resource material:

Hearing Protectors, Safety Glasses, and Respiratory Protective Equipment in Combination: Effect on Sound Attenuation
www.wsib.on.ca/wsib/wsibsite.nsf/Public/researchresultshearing

Hearing for Life brochure
http://www.wsib.on.ca/wsib/wsibsite.nsf/LookupFiles/PreventionToolsHearingforLife_3224A/$File/3224A.pdf

Hearing for Life: A Guide to Noise Control and Hearing Conservation
http://www.wsib.on.ca/wsib/wsibsite.nsf/LookupFiles/DownloadableFileNCHCGuide/$File/NCHCGuide.pdf

Noise Control & Hearing Conservation Program Audit Tool
http://www.wsib.on.ca/wsib/wsibsite.nsf/LookupFiles/DownloadableFileNoiseAuditTool/$File/NIHL_Audit.pdf

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